**Listing of Claims**

1. (Previously Presented) A method of adaptively filtering a signal transmitted over a channel, said signal containing an input signal and multiple echo responses, said multiple echo responses to be adaptively filtered, said method comprising the steps of:

generating an estimate of an echo response corresponding to each of said multiple echo responses;

generating a sum of said estimates; and

generating an error signal representing the difference between said signal and said sum of said estimates;

wherein said estimates are generated using a frequency domain recursive least squares algorithm.

2. (Previously Presented) The method set forth in claim 1 wherein each of said estimates is generated by diagonally decomposing by Fourier transformation a circulant matrix formed by augmentation of a matrix of vectors representing said input signal.

3. (Original) The method set forth in claim 1 wherein said step of generating said estimates comprises, for each of said estimates, the steps of:

forming a matrix of vectors representing said input signal;

augmenting said matrix to form a circulant matrix; and

decomposing said circulant matrix by Fourier transformation to form a diagonal matrix, D.

4. (Previously Presented) The method set forth in claim 3 wherein said step of generating said estimate further comprises the step of generating each of said estimates via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$ , and

$$\begin{aligned}\mathrm{S}(m) &= (1-\lambda_f)\sum_{p=0}^{m}\lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)\\ &= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)\end{aligned}$$ ;

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\boldsymbol{\lambda} f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}.$$

5. (Previously Presented) The method set forth in claim 3 wherein each of said estimates is generated via the equation:

$$\underline{\hat{h}}(m) = \underline{\hat{h}}(m-1) + \mu_u S_u^{-1}(m)\, D^H(m)\, \underline{e}(m).$$

where

$$\underline{e}(m) = \underline{y}(m) - \mathbf{GD}(m)\,\underline{\hat{h}}(m-1)$$, and

$$S_u(m) = \lambda_f S_u(m-1) + (1-\lambda_f)\, D^H(m)\, D(m)$$:

wherein

$\underline{\underline{\hat{h}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\boldsymbol{\lambda} f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix} .$$

6. (Previously Presented) A method for transmitting an input signal over a channel in a multiple channel communication apparatus where said input signal generates multiple echo responses and results in an output signal, wherein said multiple echo responses are adaptively filtered, said method comprising the steps of:

transmitting said signal over a channel, wherein said input signal generates at least first and second echo responses;

generating an estimate of an echo response corresponding to each of said first and second echo responses;

generating a sum of said estimates; and

generating an error signal representing the difference between said signal and sum of said estimates;

wherein said estimate are generated using a frequency domain recursive least squares algorithm.

7. (Original) The method set forth in claim 6 wherein each of said estimates is generated by diagonally decomposing by Fourier transformation a circulant matrix formed by augmentation of said input signal.

8. (Previously Presented) The method set forth in claim 6 wherein said step of generating said estimates comprises, for each of said estimates, the steps of:

forming a matrix of vectors representing said input signal;

augmenting said matrix to form a circulant matrix; and

decomposing said circulant matrix by Fourier transformation to form a diagonal matrix, D.

9. (Previously Presented) The method set forth in claim 8 wherein each of said estimates is generated via the equation:

$$\hat{\underline{\mathrm{h}}}(m) = \hat{\underline{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\hat{\underline{\mathrm{h}}}(m-1)$$ , and

$$\begin{aligned} \mathrm{S}(m) &= (1-\lambda_f)\sum_{p=0}^{m} \lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p) \\ &= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m) \end{aligned}$$ ;

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$ .

10. (Previously Presented) The method set forth in claim 8 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$ , and

$$\mathrm{S}_u(m) = \lambda_f\,\mathrm{S}_u(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{D}(m)$$ ;

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$

.

11. (Previously Presented) An apparatus for transmitting an input signal over a channel in a multiple channel communication apparatus, said apparatus comprising:

a transmitter for generating an input data signal for transmission via a communication channel, wherein said input data signal generates multiple echo responses on said channel and results in an output data signal, wherein said multiple echo responses are to be adaptively filtered;

an adaptive filter circuit for generating an estimate of an echo response corresponding to each of said multiple echo responses;

a subtracter circuit for generating an error signal representing the difference between said output data signal and a sum of said estimates;

wherein said estimates are generated using a frequency domain recursive least squares algorithm.

12. (Original) The apparatus set forth in claim 11 wherein said adaptive filter generates each of said estimates by diagonally decomposing by Fourier transformation a circulant matrix formed by augmentation of said input signal.

13. (Previously Presented) The method set forth in claim 11 wherein said adaptive filter comprises:

a circuit for forming with respect to each of said echo responses a matrix of vectors representing said input signal;

a circuit for augmenting said matrix with respect to each of said echo responses to form a circulant matrix; and

a circuit for decomposing said circulant matrix with respect to each of said echo responses by Fourier transformation to form a diagonal matrix, D.

14. (Previously Presented) The apparatus set forth in claim 13 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\mathrm{S}(m) = (1-\lambda_f)\sum_{p=0}^{m} \lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)$$

$$= \lambda_f \mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)$$

:

wherein

$\hat{\underline{\underline{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda_f$ = an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$

.

15. (Previously Presented) The apparatus set forth in claim 13 wherein each of said estimates is generated via the equation:

$$\hat{\underline{\mathrm{h}}}(m) = \hat{\underline{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$
, and

$$\mathrm{S}_u(m) = \lambda_f\,\mathrm{S}_u(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{D}(m)$$
;

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$
.

16. (Original) The apparatus set forth in claim 15 wherein said adaptive filter circuit comprises a microprocessor.

17. (Original) The apparatus set forth in claim 16 wherein said subtracter circuit comprises said microprocessor.

18. (Previously Presented) A method of multi-channel communication between at least first and second locations, said method comprising the steps of:

transmitting multiple channels of information upstream from said first location to said second location;

transmitting at least one additional channel of information downstream from said second location to said first location;

generating an estimate of an echo response corresponding to a distortion paths at said second location coupled between each of said multiple upstream channels and said downstream channel; and

generating an error signal representing the difference between a desired signal on said downstream channel and a sum of said estimates and transmitting said error signal to said first location;

wherein said estimates are generated using a frequency domain recursive least squares algorithm.

19. (Original) The method set forth in claim 18 wherein said step of generating said estimates comprises generating, by diagonally decomposing by Fourier transformation, a circulant matrix formed by augmentation of a signal on each of said upstream channels.

20. (Original) The method set forth in claim 18 wherein said step of generating said estimates comprises, for each of said estimates, the steps of:

forming a matrix of vectors representing a signal on said upstream channel;

augmenting said matrix to form a circulant matrix; and

decomposing said circulant matrix by Fourier transformation to form a diagonal matrix, D.

21. (Previously Presented) The method set forth in claim 20 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\begin{aligned}\mathrm{S}(m) &= (1-\lambda_f)\sum_{p=0}^{m} \lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)\\ &= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)\end{aligned}$$

:

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}.$$

22. (Previously Presented) The method set forth in claim 20 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\mathrm{S}_u(m) = \lambda_f\,\mathrm{S}_u(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{D}(m)$$

:

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$ .

23. (Original) The method of claim 22 further comprising the step of:

introducing a non-linear transformation into at least one of said multiple upstream channels.

24. (Original) The method as set forth in claim 23 wherein each of said estimates comprises generating a model of a distortion path at said second location from said corresponding upstream channel to said downstream channel and wherein said step of generating said estimates further comprises the steps of:

convolving each of said estimates with a signal on the corresponding one of said upstream channels to generate an estimate for each individual one of said upstream channels; and

summing each of said individual estimates.

25. (Original) The method set forth in claim 20 wherein said multiple channels of upstream information comprise sound generated at said first location and said distortion paths comprise echo paths at said second location coupled between each of said multiple upstream channels and said downstream channel.

26. (Previously Presented) A method of canceling distortion in a communication system having multiple upstream transmission channels from a first location to a second location and at least one downstream transmission channel from said second location to said first location, said method comprising the steps of:

developing an estimated echo response corresponding to each of said multiple upstream channels that models an interference path at said second location from said corresponding upstream channel to said downstream channel;

convolving each of said estimated echo responses with a signal on the corresponding one of said upstream channels to generate an estimate corresponding to each of said upstream channels; and

summing each of said estimates;

wherein said estimate is generated using a frequency domain recursive least squares algorithm.

27. (Previously Presented) The method set forth in claim 26 wherein said step of developing said estimated echo responses comprises generating, by diagonally decomposing by Fourier transformation, a circulant matrix formed by augmentation of a signal on each of said upstream channels.

28. (Previously Presented) The method set forth in claim 26 wherein said step of developing said estimated echo responses comprises, for each of said estimated echo responses, the steps of:

forming a matrix of vectors representing a signal on said upstream channel;

augmenting said matrix to form a circulant matrix; and

decomposing said circulant matrix by Fourier transformation to form a diagonal matrix, D.

29. (Previously Presented) The method set forth in claim 28 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$ , and

$$\begin{aligned}\mathrm{S}(m) &= (1-\lambda_f)\sum_{p=0}^{m}\lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)\\ &= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)\end{aligned}$$ :

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$ .

30. (Previously Presented) The method set forth in claim 28 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) \;=\; \underline{\hat{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\, \mathrm{D}^H(m)\, \underline{\mathrm{e}}(m).$$

where

and

$$\mathrm{S}_u(m) = \lambda_f\, \mathrm{S}_u(m-1) + (1-\lambda_f)\, \mathrm{D}^H(m)\, \mathrm{D}(m)$$

$$\mathrm{S}_u(m) = \lambda_f\, \mathrm{S}_u(m-1) + (1-\lambda_f)\, \mathrm{D}^H(m)\, \mathrm{D}(m)$$ :

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$ = an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}.$$

31. (Original) The method as set forth in claim 30 wherein said multiple upstream channels comprise a first channel and a second channel.

32. (Cancelled)

33. (Previously Presented) A method of canceling acoustic echo in a communication system having multiple upstream transmission channels from a first location to a second location and at least one downstream transmission channel from said second location to said first location, said method comprising the steps of:

developing an estimated echo response corresponding to each of said multiple upstream channels that models an echo path at said second location from said corresponding upstream channel to said downstream channel;

convolving each of said estimated echo responses with a signal on the corresponding one of said upstream channels to generate an estimate corresponding to each of said upstream channels; and

summing each of said estimates;

wherein said estimates are generated using a frequency domain recursive least squares algorithm.

34. (Previously Presented) The method set forth in claim 33 wherein said step of developing said estimated echo responses comprises generating, by diagonally decomposing by Fourier transformation, a circulant matrix formed by augmentation of a signal on each of said upstream channels.

35. (Previously Presented) The method set forth in claim 33 wherein said step of developing said estimated echo responses comprises, for each of said estimated echo responses, the steps of:

forming a matrix of vectors representing a signal on said upstream channel;

augmenting said matrix to form a circulant matrix; and

decomposing said circulant matrix by Fourier transformation to form a diagonal matrix, D.

36. (Previously Presented) The method set forth in claim 35 wherein each of said estimated echo responses is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\begin{aligned}\mathrm{S}(m) &= (1-\lambda_f)\sum_{p=0}^{m}\lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)\\ &= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)\end{aligned}$$

:

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\boldsymbol{\lambda} f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}.$$

37. (Previously Presented) The method set forth in claim 35 wherein each of said estimated echo responses is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$ , and

$$\mathrm{S}_u(m) = \lambda_f\,\mathrm{S}_u(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{D}(m)$$ ;

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix} .$$

38. (Previously Presented) A multi-channel teleconferencing apparatus comprising:

at least first and second upstream electrical paths between a first location and a second location for transmitting acoustic signals from said first location to said second location;

at least one downstream electrical path between said second location and said first location for transmitting acoustic signals from said second location to said first location;

at least one non-linear transformation module coupled within each of one or more of said upstream paths;

a finite impulse response filter coupled between said upstream paths and said downstream path for generating an estimate of an echo response corresponding to echo paths at said second location coupled between said at least first and second upstream channels and said downstream channel, said estimate being generated using a frequency domain recursive least squares algorithm; and

a difference circuit for generating an error signal representing the difference between a signal on said downstream channel representing sound at said second location and said estimate.

39. (Original) The apparatus set forth in claim 38 wherein said finite impulse response filter generates each of said estimates by diagonally decomposing by Fourier transformation a circulant matrix formed by augmentation of an input signal on a corresponding one of said upstream electrical paths.

40. (Previously Presented) The method set forth in claim 38 wherein said finite impulse response filter comprises:

a circuit for forming a matrix of vectors representing an input signal on a corresponding one of said upstream electrical paths;

a circuit for augmenting each of said matrices with respect to each of said echo responses to form a circulant matrix; and

a circuit for decomposing each of said circulant matrices with respect to each of said echo responses by Fourier transformation to form a diagonal matrix, D.

41. (Previously Presented) The method set forth in claim 40 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^{H}(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\mathrm{S}(m) = (1-\lambda_f)\sum_{p=0}^{m} \lambda_f^{m-p}\mathrm{D}^H(p)\,\mathrm{GD}(p)$$
$$= \lambda_f \mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)$$
:

wherein

$\hat{\underline{\underline{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$
.

42. (Previously Presented) The method set forth in claim 40 wherein each of said estimates is generated via the equation:

$$\hat{\underline{\mathrm{h}}}(m) = \hat{\underline{\mathrm{h}}}(m-1) + \mu_u \mathrm{S}_u^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\mathrm{S}_u(m) = \lambda_f \mathrm{S}_u(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{D}(m)$$

:

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}$$

.

43. (Previously Presented) The apparatus as set forth in claim 42 wherein said finite impulse response filter comprises:

a finite impulse response circuit corresponding to each of said upstream channels for generating an echo response that models an echo response corresponding to an echo path at said second location from said corresponding upstream channel to said downstream channel, each finite impulse response filter coupled between said corresponding upstream path and said downstream path.

44. (Original) The apparatus as set forth in claim 43 further comprising:

a summing circuit for summing said estimates.

45. (Original) The apparatus as set forth in claim 44 further comprising;

at least first and second microphones at said first location for receiving sound, said microphones coupled to said first and second upstream electrical paths, respectively;

at least first and second speakers at said second location coupled to said first and second upstream electrical paths, respectively, for re-creating said sound from said first location at said second location;

at least a third microphone at said second location for receiving sound, said microphone coupled to said downstream electrical path;

at least a third speaker at said first location coupled to said downstream electrical path for re-creating said sound from said second location at said first location.

46. (Previously Presented) An apparatus for performing echo cancellation in a multi-channel teleconferencing system comprising at least first and second upstream electrical paths between a first location and a second location for transmitting acoustic signals from said first location to said second location and at least one downstream electrical path between said second location and said first location for transmitting acoustic signals from said second location to said first location, said apparatus comprising;

at least one non-linear transformation module for coupling within each of one or more of said upstream paths;

a finite impulse response filter for coupling between said upstream paths and said downstream path for generating an estimate of an echo response corresponding to echo paths at said second location coupled between each of said multiple upstream channels and said downstream channel in which said estimate is generated using a frequency domain recursive least squares algorithm.

47. (Original) The apparatus set forth in claim 46 wherein said finite impulse response filter generates each of said estimates by diagonally decomposing by Fourier transformation a circulant matrix formed by augmentation of an input signal on a corresponding one of said upstream electrical paths.

48. (Previously Presented) The method set forth in claim 46 wherein said finite impulse response filter comprises:

a circuit for forming a matrix of vectors representing a an input signal on a corresponding one of said upstream electrical paths;

a circuit for augmenting each of said matrices with respect to each of said echo responses to form a circulant matrix; and

a circuit for decomposing each of said circulant matrices with respect to each of said echo responses by Fourier transformation to form a diagonal matrix, D.

49. (Previously Presented) The method set forth in claim 48 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathrm{h}}}(m) = \underline{\hat{\mathrm{h}}}(m-1) + (1-\lambda_f)\,\mathrm{S}^{-1}(m)\,\mathrm{D}^H(m)\,\underline{\mathrm{e}}(m)$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\,\underline{\hat{\mathrm{h}}}(m-1)$$

, and

$$\mathrm{S}(m) = (1-\lambda_f)\sum_{p=0}^{m} \lambda_f^{m-p}\,\mathrm{D}^H(p)\,\mathrm{GD}(p)$$

$$= \lambda_f\,\mathrm{S}(m-1) + (1-\lambda_f)\,\mathrm{D}^H(m)\,\mathrm{GD}(m)$$

:

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix}.$$

50. (Previously Presented) The method set forth in claim 48 wherein each of said estimates is generated via the equation:

$$\underline{\hat{\mathbf{h}}}(m) = \underline{\hat{\mathbf{h}}}(m-1) + \mu_u \mathbf{S}_u^{-1}(m)\,\mathbf{D}^H(m)\,\underline{\mathbf{e}}(m).$$

where

$$\underline{\mathrm{e}}(m) = \underline{\mathrm{y}}(m) - \mathrm{GD}(m)\underline{\hat{\mathrm{h}}}(m-1)$$, and

$$\mathbf{S}_u(m) = \lambda_f\,\mathbf{S}_u(m-1) + (1-\lambda_f)\,\mathbf{D}^H(m)\,\mathbf{D}(m)$$ :

wherein

$\underline{\underline{\hat{\mathrm{h}}}}$ = the frequency domain estimate of the impulse response;

m = a block time index;

$\lambda f$= an experimental forgetting factor in the frequency domain;

**D** = a diagonal matrix whose elements are the discrete Fourier transform of the first column of the circulant matrix;

$^H$ = conjugate transpose;

**e** = frequency domain error signal;

***y*** = channel output signal;

**G** = $F^{-1}WF$;

F = the Fourier matrix; and

$$W = \begin{bmatrix} 0_{LxL} & O_{LxL} \\ 0_{LxL} & I_{LxL} \end{bmatrix} .$$

51. (Previously Presented) The apparatus as set forth in claim 50 further comprising:

a difference circuit coupled to an output of said finite impulse response filter for coupling to said downstream path for generating an error signal representing the difference between a signal on said downstream path representing sound at said second location and said estimate.

52. (Previously Presented) The apparatus as set forth in claim 51 wherein said finite impulse response filter comprises:

multiple finite impulse response circuits for each of said upstream channels for generating an echo response that models an echo response corresponding to an echo path at said second location from said corresponding upstream channel to said downstream channel.